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FIFTH SCIENTIFIC MEETING**

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April 12 - 18, 1997

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Heart—Dynamics and Flow
Heart—Other
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Neuro—Chest
Neuro—Head
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Head and Neck
Musculoskeletal
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B_z-field Changes in the Brain due to Speaking and Swallowing

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INTRODUCTION:

One major concern in functional magnetic resonance imaging (fMRI) is motion of the lower part of the head, such as the jaw or the tongue, during an imaging scan. In many neuropsychological tests, for example, it is desirable to have the subject vocalize a response. In addition, physiological motions such as swallowing are an almost inescapable part of long scan procedures. Both of these can create severe artifacts, due not only to motion, but also to changes in the magnetic field. Here we investigate the B-field changes in the human brain caused by swallowing and speaking.

METHODS:

A common method of obtaining a B-field map is to acquire 2 images with different TE's (2). The extra phase accumulated by a voxel in the period ΔTE is a direct measure of the magnetic field at that point. There is an implicit assumption in this technique that there is no motion or change in the magnetic field in the time between the 2 images.

In order to measure the magnetic field throughout the imaging series, this principle was incorporated into a gradient echo - asymmetric spin echo sequence. In this technique, two images were acquired for each excitation - the first during the gradient echo, and the second during the spin echo, but offset such that the effective TE of the second image (relative to the spin echo time) is slightly longer than that of the first image (relative to the RF pulse). Because the time between the acquisition of the 2 images with differing TE's is only 100 ms., any errors in the B-field map resulting from motion or changes in the magnetic field in the time between the 2 images are minimized.

Images using the above technique were collected using a Bruker Biospec 3T/60 magnet while a subject either swallowed or alternately spoke the words "one" and "two." The gradient echo had a TE of 27.2 ms, while the spin echo had an effective TE of 47.2 ms. The TR was set to 1000 ms. The FOV was 24 cm with a matrix size of 64x64 and a slice thickness of 10mm. B-field maps were then computed by taking the complex difference of the phase of successive pairs of images having differing TE's.

Since these B-field maps are based on phase images, the magnetic field values were wrapped whenever the phase difference was greater than π or less than $-\pi$. This was corrected by using a phase unwrapping algorithm, similar to that developed by Hedley et. al. (3), but using a region growing algorithm to visit all the points in the image.

RESULTS:

B-field maps obtained using the variable TE EPI sequence are shown in figures 2 and 3, for the tasks of swallowing and speaking, respectively. The maximum B-field change measured for swallowing was -13.5 Hz (-0.11 ppm) near the inferior edge of the brain, and decreased non-linearly to -1.3 Hz (-0.01 ppm) at the superior edge. B-field changes during speaking were of similar magnitude, but depended heavily on what was being spoken. Vocalization of the word "one" produced field changes of -11.7 Hz (-0.092 ppm) near the inferior edge of the brain, and +5.3 Hz (+0.041 ppm) in the frontal lobe.

DISCUSSION:

It has been shown previously that motion outside the field of view (FOV) can cause EPI images to be warped due to changes in the magnetic field (1). This artifact becomes more pronounced the closer the motion is to the imaging plane. Swallowing and speaking therefore, although small movements, can produce significant changes in the magnetic field due to their close proximity to the brain slice being imaged. Note that the magnetic field changes in different ways depending on what is spoken. Speech that involves more jaw motion, such as speaking the word "one", produces greater changes near the frontal lobe than speech that involves only small movements, such as the word "two." (See figure 3).

The severe artifacts seen in functional MR images as a result of speaking or swallowing has most commonly been attributed to the physical motion in the FOV. As shown here, however, a significant component of this artifact is due to changes in the magnetic field caused by motion outside the FOV, but near the slice being imaged, making image registration difficult. Successful correction of this artifact therefore requires that both physical motion and B-field changes during the imaging scan are considered.

REFERENCES:

1. F.Z.Yetkin, W.M. Haughton, et al., Am J Neurorad., 17, 1005-1009, 1996.
2. P. Jezzard, R.S. Balaban, Magn. Res. Med. 34, 65-73, 1995.
3. M. Hedley, D. Rosenfeld, Magn. Res. Med., 24, 177-181, 1992.



Figure 1 (left): Magnitude EPI image of the sagittal brain slice used for the B-field maps

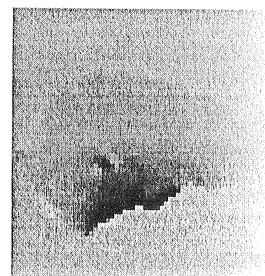


Figure 2 (right): Maximum magnetic field changes during swallowing. Dark regions represent negative changes, and gray areas represent no change.

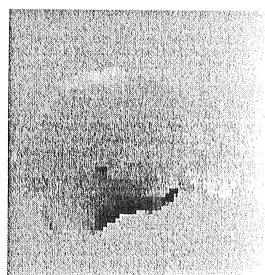
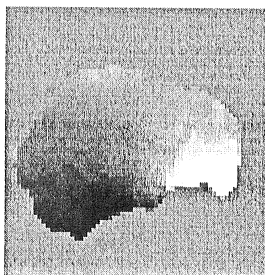


Figure 3: Maximum magnetic field change during speaking the words "one" (left) and "two" (right). All three B-field maps shown above have been scaled identically.